What do we mean by Cosmic Catastrophy?

The universe is a violent place. Most objects change almost imperceptibly. Others have violent outbursts which can last anywhere from a few minutes to months. Even our sun is not quiet and produces flares which eject high energy particles which from time to time are in densities high enough to slightly irradiate those well-off individuals who could until recently ride on the Concord supersonic transport. Astronauts are also at risk and for strong flares would have to take shelter inside portions of the International Space Station where there is more shielding.

The most violent events in the universe are associated with black holes and with dying stars. Sometimes but not always, the dying star produces a black hole. A single dying star in its final supernova outburst can for a period of about a week produce a far higher rate of energy output than an entire galaxy.

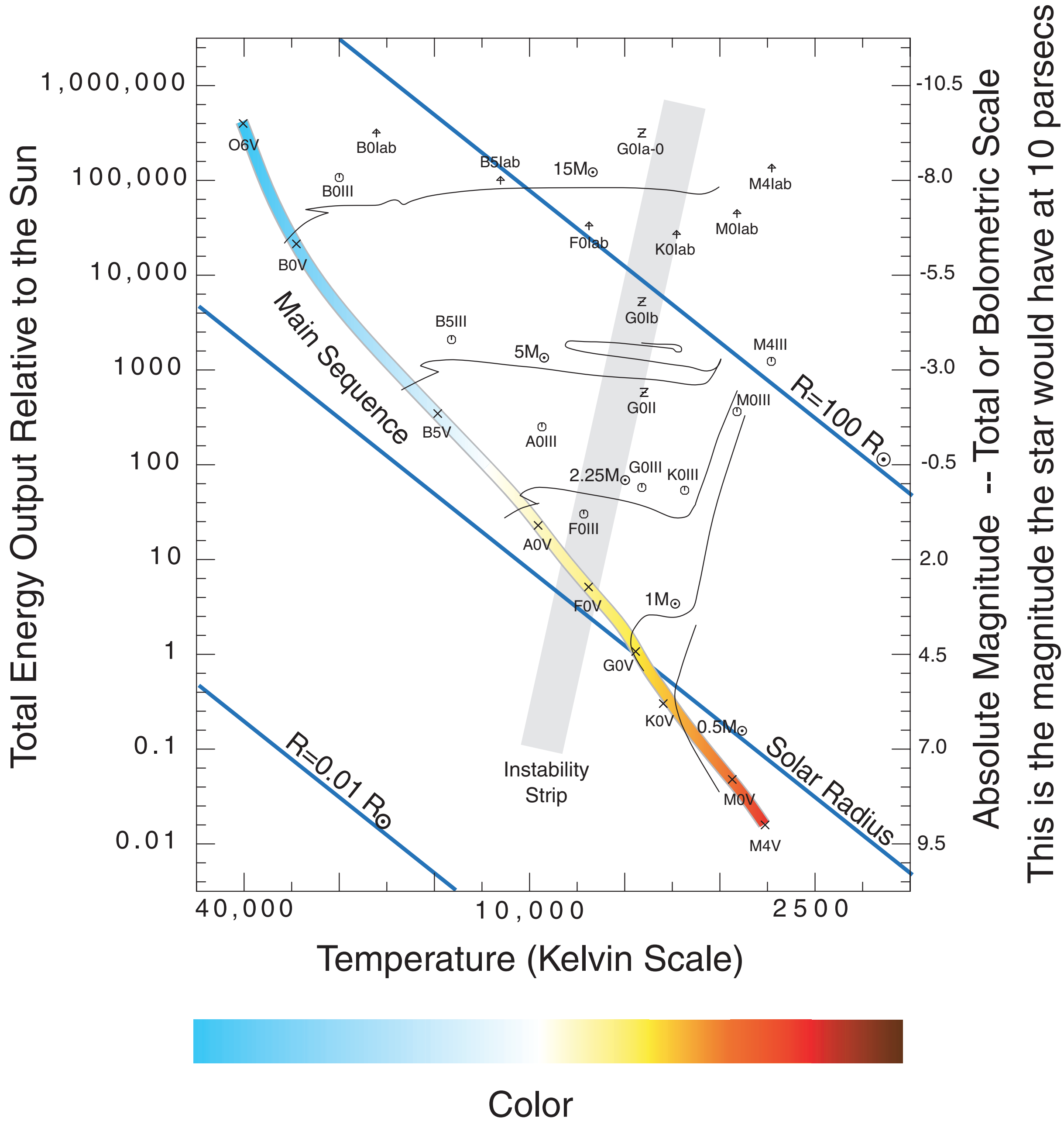
Many and perhaps most galaxies including our own have at their center a large black hole. Matter flowing into this black hole releases energy from the gravitational attraction and some of this energy escapes to be detectable by use and to heat the surrounding gas near the galactic center.

We can study other black holes which are gravitationally bound to another star. Matter ejected by the normal star can be captured by the black hole and converted to radiation in a small version of what we think happens near the galactic center.

Through this quarter we will build toward a deeper understanding of how these violent events take place.

A starting point is the Hertzsprung Russell diagram which was introduced in Astronomy 3 and which should be familiar to all participants in this course. The next few slides review properties of the HR diagram and discuss its use.

Review of the Hertzsprung-Russell Diagram



This schematic diagram illustrates a number of points that will be used throughout the quarter. Note in particular: a) The masses of the stars can be estimated if they can be placed on the HR diagram, b) Smaller stars tend to be low luminosity unless they have high temperatures, c) Aging stars tend to become large just before they end their lives.

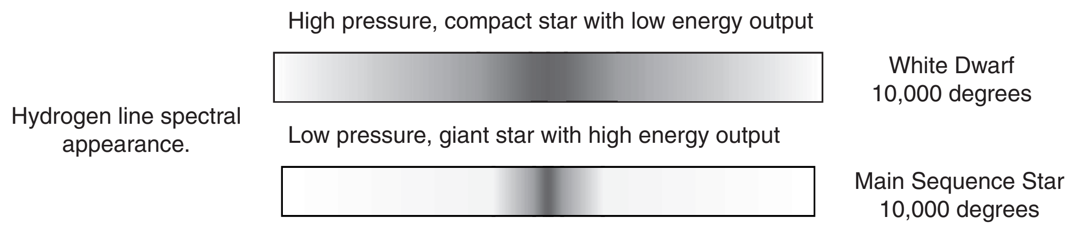
What is a Hertsprung-Russell Diagram?

Measurement of stars:

1. We measure the apparent brightness of a star in various colors of light.

2. We measure the temperature indirectly by measuring the color or by measuring the strengths of absorption lines in the spectra of the stars.

3. We can estimate the luminosity of a star from the width of its spectral lines:



4. Sometimes we measure the masses of the stars when they are members of binary systems (two stars in orbit around each other).

5. We measure the abundances of the elements making up the star from the strengths of their absorption lines.

After correcting for the effects of variable distance and the fact that we usually do not measure all the radiation from the star because it comes in wavelengths outside the normally measurable range, we can plot the stars' positions on the Hertzsprung-Russell diagram. We find:

1. Most stars are found near the Main Sequence.

2. Stars that are aged are typically but not always Red Giants.

3. Some stars have very small radii and are called White Dwarfs.

Why do we use the HR Diagram so much?

1. By setting up the mathematical equations which stars must obey and incorporating the best physical description of the matter which makes up the stars, we can compute theoretical paths stars should follow on the HR diagram. Some of these are shown in abbreviated form on the figure of slide 2. The HR diagram is the meeting place for theoretical and observational stellar astronomers.

2. After measuring or estimating the properties of a star and making the appropriate corrections, we can plot its position on the HR diagram. By determining which theoretical stellar evolution path is closest to the star's position, we can estimate the star's mass and evolutionary state.

3. Some stars like white dwarfs do not fall on evolutionary tracks which can be computed from the main sequence to the end of a star's life. For these, the position on the HR diagram helps estimate the star's radius which in turn helps determine how the star got to where it is.

4. The HR diagram helps clarify why the very small stars like white dwarfs or even more extreme in terms of small radius, like the neutron stars, must have very high surface temperatures in order to be detectible. Without the high surface temperature, they are simply too faint to be found. Because of the required high temperature, neutron stars and to some extent the white dwarfs, must be detected using the kind of radiation emitted by high temperature gas — the X-rays or even γ-rays in the case of neutron stars.